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(54) Micro-denier nonwoven materials made using modular die units

Mikrodenier Vliesstoffe hergestellt unter Verwendung modularer Spinndüseneinheiten

Microdenier non-tissés préparés à l'aide d'unités de plaques de filières modulaires

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to micro-denier nonwoven webs and their method of production using modular die units in an extrusion and blowing process.

DESCRIPTION OF THE PRIOR ART

[0002] Thermoplastic resins have been extruded to form fibers and webs for many years. The nonwoven webs so produced are commercially useful for many applications including diapers, feminine hygiene products, medical and protective garments, filters, geotextiles and the like.

[0003] A highly desirable characteristic of the fibers used to make nonwoven webs for certain applications is that they be as fine as possible. Fibers with small diameters, less than 10 microns, result in improved coverage and higher opacity. Small diameter fibers are also desirable since they permit the use of lower basis weights or grams per square meter of nonwoven. Lower basis weight, in turn, reduces the cost of products made from nonwovens. In filtration applications small diameter fibers create correspondingly small pores which increase the filtration efficiency of the nonwoven

[0004] The most common of the polymer-to-nonwoven processes are the spunbond and meltblown processes. They are well known in the US and throughout the world. There are some common general principles between melt blown and spunbond processes. The most significant are the use of thermoplastic polymers extruded at high temperature through small orifices to form filaments and using air to elongate the filaments and transport them to a moving collector screen where the fibers are coalesced into a fibrous web or nonwoven.

[0005] In the typical spunbond process the fiber is substantially continuous in length and has a fiber diameter typically in the range of 20 to 80 microns. The meltblown process, on the other hand, typically produces short, discontinuous fibers that have a fiber diameter of 2 to 6 microns.

[0006] Commercial meltblown processes, as taught by US Patent 3,849,241 to Buntin, et al, use polymer flows of 1 to 3 grams per hole per minute at extrusion pressures from 2756 to 6890 kilopascals (400 to 1000 psig) and heated high velocity air streams developed from an air pressure source of 4134 or more kilopascals (60 or more psi) to elongate and fragment the extruded fiber. This process also reduces the fiber diameter by a factor of 190 (diameter of the die hole divided by the average diameter of the finished fiber) compared to a diameter reduction factor of 30 in spunbond processes. The typical meltblown die directs air flow from two opposed nozzles situated adjacent to the orifice such that they meet at an acute angle at a fixed distance below the polymer orifice exit. Depending on the air pressure and velocity and the polymer flow rate the resultant fibers can be discontinuous or substantially continuous. In practice, however, the continuous fibers made using accepted meltblown art and commercial practice are large diameter, weak and have no technical advantage. Consequently the fibers in commercial meltblown webs are fine (2-10 microns in diameter) and short, typically being less than 12.7 mm (0.5 inches) in length.

[0007] It is well known in the nonwoven industry that, in order to be competitive in melt blowing polymers, from both an equipment and a product standpoint, polymer flows per hole must be at least 1 gram per minute per hole as disclosed by U. S. Patent 5,271,883 to Timmons et al. If this is not the case additional dies or beams are required to produce nonwovens at a commercially acceptable rate. Since the body containing the die tips and the die tips themselves as used in standard commercial melt blowing die systems are very expensive to produce, multiple die bodies make low polymer and low air flow systems unworkable from an operational and an economic viewpoint. It is additionally recognized that the high air velocities coupled with the very large volumes of air created in a typical meltblown system creates considerable turbulence around the collector. This turbulence prevents the use of multiple rows of die holes especially if for technical or product reasons the collector is very close to the die holes. Additionally, the extremely high cost of machining makes multiple rows of die holes enclosed in a single die body cost prohibitive.

[0008] Presently the art of blowing or drawing fibers, composed of the various thermally extrudable organic and inorganic materials, is limited to the use of subsonic air flows although the achievement of supersonic flows would be advantageous in certain meltblown and spunbond applications. It is well known from fluid dynamics, however, that in order to develop supersonic flows in compressible fluids, such as air, a specially designed convergent-divergent nozzle must be used. However, it is virtually impossible to provide the correct convergent-divergent profile for a nozzle by machining a monolithic die especially when large numbers of nozzles are required in a small space.

SUMMARY OF THE INVENTION

[0009] The instant invention is a new method of making nonwoven webs, mats or fleeces wherein a multiplicity of filaments are extruded at low flows per hole from a single modular die body or a series of modular die bodies wherein

each die body contains one or more rows of die tips. The modular construction permits each die hole to be flanked by up to eight air jets depending on the component plate design of the modular die.

[0010] The air used in the instant invention to elongate the filaments is significantly lower in pressure and volume than presently used in commercial applications. The instant invention is based on the surprising discovery that using the modular die design, in a melt blowing configuration at low air pressure and low polymer flows per hole, continuous fibers of extremely uniform size distribution are created, which fibers and their resultant unbonded webs exhibit significant strength compared to typical unbonded meltblown or spunbond webs. In addition substantial self bonding is created in the webs of the instant invention. Further, it is also possible to create discontinuous fibers as fine as 0.1 microns by using converging-diverging supersonic nozzles.

[0011] For purposes of defining the air flow characteristics of the instant invention the term "blowing" is assumed to include blowing, drafting and drawing. In the typical spunbond system the only forces available to elongate the fiber as it emerges from the die hole is the drafting or drawing air. This flow is parallel to the fiber path. In the typical melt blown system the forces used to elongate the fiber are directed at an oblique angle incident to the surface. The instant invention uses air to produce fiber elongation by forces both parallel to the fiber path and incident to the fiber path depending on the desired end result.

[0012] Accordingly, it is an object of the present invention to produce a unique nonwoven web using the modular extrusion die apparatus described in the US application serial number 08/370,383 by Fabbricante, et al whereby specially shaped plates are combined in a repeating series to create a sequence of readily and economically manufactured modular die units which are then contained in a die housing which is a frame or holding device that contains the modular plate structure and accommodates the design of the molten polymer and heated air inlets. The cost of a die produced from that invention is approximately 10 to 20% of the cost of an equivalent die produced by traditional machining of a monolithic block. It is also critical to note that it is virtually impossible to machine a die having multiple rows of die holes and multiple rows of air jets.

[0013] Because of the modular die invention and its inherent economies of manufacture it is possible for multiple rows of die holes and multiple die bodies to be used without high capital costs. This in turn permits low flows per hole with concomitant ability to use low melt pressures for fiber extrusion and low air pressures for elongating these filaments. As an example, in an experimental meltblown die configuration, flows of less than 0.1 grams per hole per minute and using heated air at 34 kilopascals (5 psig) pressure create a strong self bonded web of 2 micron fibers. The web may also be thermally bonded to provide even greater strength by using conventional hot calendering techniques where the calender rolls may pattern engraved or flat.

[0014] Another unexpected result is that because of the low pressure air and low flow volumes, even though the die bodies contains multiple rows of die tips, there is virtually no resultant turbulence that would create fiber entanglement and create processing problems.

[0015] A further unforeseen result of the instant invention is that the combination of multiple rows of die holes with multiple offset air jets all running at low polymer and air pressure do not create polymer and air pressure balancing problems within the die. Consequently the fiber diameter, fiber extrusion characteristics and web appearance are extremely uniform.

[0016] A further invention is that the web produced has characteristics of a meltblown material such as very fine fibers (from 0.6 to 8 micron diameter), small inter-fiber pores, high opacity and self bonding, but surprisingly it also has characteristics of a spunbond material such as substantially continuous fibers and high strength when bonded using a hot calender

[0017] A further invention is that when a die using a series of converging-diverging nozzles, either in discrete air jets or continuous slots which are capable of producing supersonic drawing velocities, wherein the flow of the nozzles is parallel to the centerline of the die holes, which die holes have a diameter greater than 0.38 mm (0.015 inches), the web produced without the use of a quench air stream has fine fibers (from 5 to 20 microns in diameter dependent on die hole size, polymer flow rates and air pressures), small inter-fiber pores, good opacity and self bonding but, surprisingly, it has characteristics of a spunbond material such as substantially continuous fibers and high strength when bonded using hot calender. It is important to note that a quench stream can easily be incorporated within the die configuration if required by specific product requirements.

[0018] A further invention is that when a die using a series of converging-diverging nozzles, which are capable of producing supersonic drawing velocities, wherein the angle formed between the axis of the die holes and supersonic air nozzles varies between 0° and 60°, and which die holes have a diameter greater than 0.13 mm (0.005 inches), the web produced has fine fibers (from 0.1 to 2 microns in diameter dependent on die hole size, polymer flow rates and air pressures), extremely small inter-fiber pores, good opacity and self bonding.

DESCRIPTION OF THE INVENTION

[0019] The present invention is a novel method for the extrusion of substantially continuous filaments and fibers

using low polymer flows per die hole and low air pressure resulting in a novel nonwoven web or fleece having low average fiber diameters, improved uniformity, a narrow range of fiber diameters, and significantly higher unbonded strength than a typical meltblown web. When the material is thermally point bonded it is similar in strength to spunbonded nonwovens of the same polymer and basis weight. This permits the manufacture of commercially useful webs having a basis weight of less than 12 grams/square meter.

[0020] Another important feature of the webs produced are their excellent liquid barrier properties which permit the application of over 50 cm of water pressure to the webs without liquid penetration.

[0021] Another feature of the present invention is that the modular die units may be mixed within one die housing thus simultaneously forming different fiber diameters and configurations which are extruded simultaneously, and when accumulated on a collector screen or drum provide a web wherein the fiber diameters can be made to vary along the Z axis or thickness of the web (machine direction being the X axis and cross machine direction being the Y axis) based on the diameters of the die holes in the machine direction of the die body.

[0022] Yet another feature of the present invention is that multiple extrudable materials may be utilized simultaneously within the same extrusion die by designing multiple polymer inlet systems.

[0023] Still another feature of the present invention is that since multiple extrudable molten thermoplastic resins and multiple extrusion die configurations may be used within one extrusion die housing, it is possible to have both fibers of different material and different fiber diameters or configurations extruded from the die housing simultaneously.

[0024] The novel features which are considered characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of the specific embodiments when read in connection with the accompanying drawings.

[0025] It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the type described above including but not limited to webs derived from thermoplastic polymers, thermoelastic polymers, glass, steel, and other extrudable materials capable of forming fine fibers of commercial and technical value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] These features as well as others, shall become readily apparent after reading the following description in conjunction with the accompanying drawings in which:

FIG. 1 is a sectional view illustrating the primary plate and secondary plate that illustrates the arrangement of the various feed slots where there is both a molten thermoplastic resin flow and an air flow through the modular die and both the polymer die hole and the air jet are contained in the primary plate.

FIG. 2 shows how primary and secondary die plates in the modular plate construction can be used to provide 4 rows of die holes and the required air jet nozzles for each die hole.

FIG. 3 is a plan view of three variations on the placement of die holes and their respective air jet nozzles in a die body with 3 rows of die holes in the cross-machine direction.

FIG. 4 illustrates the incorporation of a converging-diverging supersonic nozzle in a primary modular die plate for the production of supersonic air or other fluid flows.

DETAILED DESCRIPTION OF SOME OF THE PREFERRED EMBODIMENTS

[0027] The melt blown process typically uses an extruder to heat and melt the thermopolymer. The molten polymer then passes through a metering pump that supplies the polymer to the die system where it is fiberized by passage through small openings in the die called, variously, die holes, spinneret, or die nozzles. The exiting fiber is elongated and its diameter is decreased by the action of high temperature blowing air. Because of the very high velocities in standard commercial meltblowing the fibers are fractured during the elongation process. The result is a web or mat of short fibers that have a diameter in the 2 to 10 micron range depending on the other process variables such as hole size, air temperature and polymer characteristics including melt flow, molecular weight distribution and polymeric species.

[0028] Referring to **Figure 1** of the drawings a modular die plate assembly **7** is formed by the alternate juxtaposition of primary die plates **3** and secondary die plates **5** in a continuing sequence. A fiber forming, molten thermoplastic resin is forced under pressure into the slot **9** formed by secondary die plate **5** and primary die plate **3** and secondary die plate **5**. The molten thermoplastic resin, still under pressure, is then free to spread uniformly across the lateral

cavity **8** formed by the alternate juxtaposition of primary die plates **3** and secondary die plates **5** in a continuing sequence. The molten thermoplastic resin is then extruded through the orifice **6**, formed by the juxtaposition of the secondary plates on either side of primary plate **3**, forming a fiber. The size of the orifice that is formed by the plate juxtaposition is a function of the width of the die slot **6** and the thickness of the primary plate **3**. The primary plate **3** in this case is used to provide two air jets **1** adjacent to the die hole. It should be recognized that the secondary plate can also be used to provide two additional air jets adjacent to the die hole.

[0029] The angle formed between the axis of the die hole and the air jet slot that forms the air nozzle or orifice **6** can vary between 0° and 60° although in this embodiment a 30° angle is preferred. In some cases there may be a requirement that the exit hole be flared.

[0030] Referring to **Figure 2** this shows how the modular primary and secondary die plates are designed to include multiple rows of die holes and air jets. The plates are assembled into a die in the same manner as shown in **Figure 1**.

[0031] Referring to **Figure 3** we see a plan view of the placement of die holes and air jet nozzles in three different die bodies **Figures 3a, 3b** and **3c** each with 3 rows **21, 22, 23** of die holes and air jets in the machine direction of the die. The result is a matrix of air nozzles and melt orifices where their separation and orientation is a function of the plate and slot design and primary and secondary plate(s) thickness. Figure **3a** shows a system wherein the die holes **20** and the air jets **17** are located in the primary plate **24** with the secondary plate **25** containing only the polymer and air passages. In this embodiment each die hole along the width of the die assembly has eight air jets immediately adjacent to it. Two jets in each primary plate impinge directly upon the fiber exiting the die hole while the other six assist in drawing the fiber with an adjacent flow.

[0032] Figure **3b** shows a system wherein the die holes **20** are located only in the primary plate and the air jets are located in both the primary **26** and secondary plates **27** thereby creating a continuous air slot **18** on either side of the row of die holes.

[0033] Figure **3c** shows a system wherein the die holes **20** are located only in the primary plate **28** and the air jets are located in the secondary plates **29** thereby creating air jets **19** on either side of the row of die holes. This adjacent flow draws without impinging directly on the fiber and assists in preserving the continuity of the fiber without breaking it. This configuration provides four air jets per die hole.

[0034] While it is not shown, it is clear from the above that a juxtaposed series of only primary plates would provide a slit die that could be used for film forming.

[0035] Consequently the instant invention presents the ability to extend the air and melt nozzle matrix a virtually unlimited distance in the lateral and axial directions. It will be apparent to one versed in the art how to provide the polymer and air inlet systems to best accommodate the particular system being constructed. The modular die construction in this particular embodiment provides a total of 4 air nozzles for blowing adjacent to each die hole although it is possible to incorporate up to 8 nozzles adjacent to each die hole. The air, which may be at temperatures of up to 482° C (900° F), provides a frictional drag on the fiber and attenuates it. The degree of attenuation and reduction in fiber diameter is dependent on the melt temperature, die pressure, air pressure, air temperature and the distance from the die hole exit to the surface of the collector screen.

[0036] It is well known in the art that very high air velocities will elongate fibers to a greater degree than lower velocities. Fluid dynamics considerations limit slot produced air velocities to sonic velocity. Although it is known how to produce supersonic flows with convergent-divergent nozzles this has not been successfully accomplished in meltblown or spunbond technology. It is believed that this is due to the considerable difficulty or impossibility of producing a large number of convergent-divergent nozzles in a small space in conventional monolithic die manufacturing.

[0037] **Figure 4** illustrates how this can be accomplished within the modular die plate configuration. Only a primary plate **3** is shown. In practice the secondary plate would be similar to that shown in **Figure 1**. The primary plate contains a die hole **6** and two converging-diverging nozzles. **Figure 4** shows how the lateral air passage **14** provides pressurized air to the converging duct section **13** which ends in a short orifice section **12** connected to the diverging duct section **11** and provides, in this case, two incident supersonic flows impinging on the fiber exiting the die hole. This arrangement provides very high drafting and breaking forces resulting in very fine (less than 1 micron diameter) short fibers.

[0038] This general method of using modular dies to create a multiplicity of convergent-divergent nozzles can also be used to create a supersonic flow within a conventional slot draw system as currently used in spunbond by using an arrangement wherein the converging-diverging nozzles are parallel to the die hole axis rather than inclined as shown in **Figure 4**. An alternative to the two air nozzles per die hole arrangement is to use the nozzle arrangement of **Figure 3b** wherein the primary and secondary plates all contain converging-diverging nozzles resulting in a continuous slot converging-diverging nozzle.

[0039] In the typical meltblown application the extrusion pressure is between 400 and 1000 pounds per square inch. This pressure causes the polymer to expand when leaving the die hole because of the recoverable elastic shear strain peculiar to viscoelastic fluids. The higher the pressure, the greater the die swell phenomena. Consequently at high pressures the starting diameter of the extrudate is up to 25% larger than the die hole diameter making fiber diameter reduction more difficult. In the instant embodiment the melt pressure typically ranges from 1378 to 13780 kilopascals

(20 to 200 psig). The specific pressure depends on the desired properties of the resultant web. Lower pressures result in less die swell which assists in further reduction of finished fiber diameters.

[0040] The attenuated fibers are collected on a collection device consisting of a porous cylinder or a continuous screen. The surface speed of the collector device is variable so that the basis weight of the product web can increased or decreased.. It is desirable to provide a negative pressure region on the down stream side of the cylinder or screen in order to dissipate the blowing air and prevent cross currents and turbulence.

[0041] The modular design permits the incorporation of a quench air flow at the die in a case where surface hardening of the fiber is desirable. In some applications there may be a need for a quench air flow on the fibers collected on the collector screen.

[0042] Ideally the distance from the die hole outlet to the surface of the collector should be easily varied. In practice the distance generally ranges from 76 to 914 mm (3 to 36 inches). The exact dimension depends on the melt temperature, die pressure, air pressure and air temperature as well as the preferred characteristics of the resultant fibers and web.

[0043] The resultant fibrous web may exhibit considerable self bonding. This is dependent on the specific forming conditions. If additional bonding is required the web may be bonded using a heated calender with smooth calender rolls or point bonding.

[0044] The method of the invention may also be used to form an insulating material by varying the distance of the collector means from the die resulting in a low density web of self-bonded fibers with excellent resiliency after compression.

[0045] The fabric of this invention may be used in a single layer embodiment or as a multi-layer laminate wherein the layers are composed of any combination of the products of the instant invention plus films, woven fabrics, metallic foils, unbonded webs, cellulose fibers, paper webs both bonded and debonded, various other nonwovens and similar planar webs suitable for laminating. Laminates may be formed by hot melt bonding, needle punching, thermal calendering and any other method known in the art. The laminate may also be made in-situ wherein a spunbond web is applied to one or both sides of the fabric of this invention and the layers are bonded by point bonding using a thermal calender or any other method known in the art.

EXAMPLES

[0046] Several self bonded nonwoven webs were made from a meltblowing grade of Philips, 35 melt flow polypropylene resin using a modular die containing a single row of die holes. The length of a side of the square spinneret holes was 0.381 mm (0.015 inches) and the flow per hole varied from 0.05 to 0.1 grams/hole/minute at 1034 kilopascals (150 psig). Air pressure of the heated air flow was varied from 28 to 69 kilopascals (4 to 10 psig). Fiber diameter, web strength and hydrostatic head (inches of water head) were measured. The fibers were collected on a collector cylinder capable of variable surface speed.

Table 1

Trial Run	Air Pressure	Flow Rate	Basis Wt	Microns	H_2O head	Break Load
1	4	0.05	10.3	2.7	20	241
2	4	0.10	17.8	2.9	>30	456
3	6	0.05	11.7	2.2	>30	299
4	6	0.10	16.5	2.7	>30	423
5	10	0.05	12.1	1.9	>30	270

[0047] The results shown in Table 1 show that the method of the invention unexpectedly produced a novel web state with significant self bonding with surprising strength in the unbonded and with excellent liquid barrier properties.

[0048] In another example several self bonded nonwoven webs of were made from a meltblowing grade of Philips polypropylene resin using a die with three rows of die holes across the width of the die. The length of a side of the square spinneret holes was 0.015 inches and the flow per hole varied from 0.05 to 0.1 grams/hole/minute at 1034 kilopascals (150 psig). Air pressure of the heated air flow was varied from 27.6 to 68.9 kilopascals (4 to 10 psig). The fibers were collected on a collector cylinder capable of variable surface speed. Fiber diameter, web strength and hydrostatic head in cm of water head (inches of water head) were measured.

Table 2

Trial Run	Air Pressure	Flow Rate	Basis Wt	Microns	H_2O head	Break Load
6	5	0.11	34.6	2.9	>45	847
7	4.5	0.10	25.4	3.0	>45	671
8	6	0.10	30	2.5	>45	815

[0049] The results shown in Table 2 unexpectedly show that the method of the invention produced a novel web with surprising strength in the unbonded state and with excellent liquid barrier properties.

[0050] In still another example self bonded nonwoven webs were made from a meltblowing grade of Philips polypropylene resin in a modular die containing a single row of die holes. In this case the drawing air was provided from four converging-diverging supersonic nozzles per die hole. The converging-diverging supersonic nozzles were placed such that their axes were parallel to the axis of the die hole. The angle of convergence was 7° and the angle of divergence was 7°. The length of a side of the square spinneret holes was 0.64 mm (0.025 inches) and the polymer flow per hole was 0.2 grams/hole/minute at 1723 kilopascals (250 psig). Air pressure was 103 kilopascals (15 psig). The fibers were collected on a collector cylinder capable of variable surface speed. A quench air stream was directed on to the collector. Fiber diameter and web strength were measured.

Table 3

Trial Run	Air Pressure	Flow Rate	Basis Wt	Microns	Break Load
9	15	0.25	15.3	12.1	548

[0051] The results shown in table 3 demonstrate that the method of the invention produced a novel web with surprising strength in the unbonded state and continuous fibers and a web appearance similar to spunbond material. Microscopic examination of the resultant webs showed excellent uniformity, no shot and no evidence of twinned fibers or fiber bundles and clumps due to turbulence.

[0052] In yet another example self bonded nonwoven webs were made from a meltblowing grade of Philips polypropylene resin in a modular die containing a single row of die holes. In this case the drawing air was provided from four converging-diverging supersonic nozzles per die hole. The converging-diverging supersonic nozzles were inclined at a 60° angle to the axis of the die hole. The length of a side of the square spinneret holes was 0.381 mm (0.015 inches) and the flow per hole was 0.11 grams/hole/minute at 861 kilopascals (125 psig). Air pressure of the air flow was 861 kilopascals (15 psig). The fibers were collected on a collector cylinder capable of variable surface speed. Fiber diameter and web strength were measured. These results are shown in Table 4.

Table 4

Run	Air Pressure	Flow Rate	Basis Wt	Microns	Break Load
10	15	0.11	25.3	0.5	622

[0053] The results show that the method of the invention produced a novel web with surprisingly small diameter fibers, adequate strength in the unbonded state and a mix of continuous and discontinuous fibers. Microscopic examination of the resultant webs showed excellent uniformity and no evidence of twinned fibers or fiber bundles and clumps due to turbulence.

Claims

1. A modular extrusion die body for extruding fibers from molten, synthetic, thermoplastic, polymeric resins comprising;

   (a) a stack of alternating primary and secondary die plates;
   (b) said primary and secondary die plate having :aligned top and bottom edges separated by no more than 0.15 meters;
   (c) each of said primary and secondary die plates having a central opening there through, the central openings in said die plates communicating with each other to form a single, continuous pressure equalization chamber within said die body extending through a central region of said die body;

(d) the top edge of each said primary die plate having an opening to receive molten polymeric resin, said opening communicating with said chamber permitting said polymeric resin to enter said chamber wherein each orifice is equidistant from the feed manifold;
(e) a top surface of said die body wherein the total area of the openings on said top surface is at least forty percent of the total area described by the width of the opening and length measured across all of the primary and secondary die plates;
(f) the bottom edge of each said secondary die plate having an extrusion slot extending to said chamber, the adjacent primary die plates forming with said extrusion slot an orifice for the extrusion of said polymer resin.: and
(g) a means for delivering a stream of fluid adjacent each said orifice comprising a passage way extending the length of said die body passing through all of said die plates, and a channel in each said secondary plate from said passageway to and terminating at the bottom edge of said secondary plate in a nozzle for delivering said fluid adjacent the extrude resin;
(h) an equalization chamber segment formed by and within each combination of adjacent primary and secondary plates which has a volume of at least 2,000 times and no more than 40,000 times the volume of the orifice;
(i) a means to maintain the multiplicity of modules in sealed alignment with each other.

2. A nonwoven fabric having fibers smaller in diameter than 1 micron wherein said fibers are continuous in length, self bonded and stronger in tensile strength than fibers prepared by other meltblown methods and which is produced according to the method of:

(a) melting at least one polymer by an extrusion means,
(b) extruding said polymer at flow rates of less than 1 gram per minute per hole through the die holes of the modular die of claim 1, said modular die containing one or more rows of die holes in the cross machine direction wherein said die is heated by a heating means;
(c) blowing said polymer extrudate, using heated air of at least 93° C (200°F), from two or more low pressure air jets per die hole wherein said air pressure is less than 345 kilopascals (50 psig), into fibers of 1 micron, or less in diameter, and depositing said fibers on a collecting means, located less than 1270 mm (50 inches) from said die, to form a web of dispersed fibers weighing 4 grams or more per square meter.

3. A low density insulation web produced according to the method of claim 2.

4. The nonwoven fabric of claim 2 wherein said polymer is selected from the group of thermopolymers consisting of olefins and their copolymers, styrenics and their copolymers, polyamides, polyesters and their copolymers, halogenated polymers, and thermoelastic polymers and their copolymers.

5. The nonwoven web produced according to the method of claim 2 wherein a layer of spunbond material is deposited onto said web and the resultant laminate is calendered using a heated point bonding calender.

6. The nonwoven web produced according to the method of claim 2 wherein a layer of spunbond material is deposited onto each side of said web and the resultant laminate is calendered using a heated point bonding calender.

7. A filtration material from the nonwoven web of claim 2 wherein the fibers of said web produced from each row of die holes, which have progressively smaller diameters, and said fibers are progressively smaller and range from 0.1 to 10 microns depending on the diameter of said die holes.

8. The electrostatically charged, nonwoven web of claim 2 which is a filter.

9. A method for manufacturing a nonwoven web which comprises:

(a) melting at least one polymer by a polymer heating and extrusion means;
(b) extruding said polymer at flow rates of less than 1 gram per minute per hole through the die holes of a modular die containing one or more rows of die holes said die being heated by a heating means;
(c) blowing said polymer extrudate, using heated air of at least 93° C (200°F), or more, from 2 or more low pressure air jets per die hole to produce fibers of 20 microns or less in diameter, and; depositing said fiberized polymer on a collecting means to form a web of disbursed fibers weighing 4 grams or more per square meter.

10. The method of claim 9 wherein said die, with more than one row of die holes is used in the cross machine direction of the die and each row has a progressively smaller die hole than the preceding row.

11. The method of claim 9 wherein the modular die has means for extruding two or more polymers from the same die.

12. The method of claim 9 wherein two or more extrusion means are used in conjunction with one or more said modular dies, wherein each of said extrusion means supplies one or more modular dies.

13. The method of claim 9 wherein said air pressure is less than 345 kilopascals. (50 psig).

14. The method of claim 9 where said fibers are quenched on said collector screen by a fluid stream wherein said fluid stream has a temperature of less than 93° C (200° F),.

15. The method of claim 9 wherein the die holes in separate rows are of different diameters yielding different diameter fibers.

16. The method of claim 9 wherein the angle formed between the vertical. axis of the die hole and the exit slot that forms the air nozzle or orifice can .vary between 0° and 60°.

17. The method of claim 9 wherein a converging- diverging nozzle is used in place of an constant cross-section air slot.

18. The method of claim 17 wherein the converging portion of said nozzle converges at an angle of no less than 2 degrees from the centerline of said nozzle and no more than 18 degrees; and the diverging portion of said nozzle diverges at an angle of no less than 3 degrees and no more than 18 degrees from the centerline of said nozzle.

19. The method of claim 9 wherein 2 or more air nozzles or air slots are adjacent to each die hole.

20. The method of claim 9 wherein drafting air is delivered from modular air systems incorporating continuous converging-diverging nozzle slots, said systems being placed below and adjacent to said die hole exits wherein said continuous converging-diverging nozzle slots form a high speed air curtain on either side of the polymer extrudate wherein said high speed air curtains may be separated from the said high speed air curtains of any adjacent die hole rows by plates positioned perpendicular to the surface of said modular die wherein,said plates form a discrete channel for the drawing of said extrudate by said high speed air curtains.

Patentansprüche

1. Modularer Extrusionsdüsenkörper zum Extrudieren von Fasern aus geschmolzenen synthetischen thermoplastischen Polymerharzen, umfassend:

   (a) einen Stapel von abwechselnden primären und sekundären Düsenplatten;
   (b) wobei die primäre und sekundäre Düsenplatte fluchtende obere und untere Ränder aufweisen, die nicht mehr als 0,15 m auseinander liegen;
   (c) wobei jede der primären und sekundären Düsenplatten eine durchgehende mittlere Öffnung aufweist, wobei die mittleren Öffnungen in den Düsenplatten miteinander kommunizieren, um innerhalb des Düsenkörpers eine einzige durchgehende Druckausgleichskammer zu bilden, die sich durch einen mittleren Bereich des Düsenkörpers erstreckt;
   (d) wobei der obere Rand von jeder primären Düsenplatte eine Öffnung aufweist, um geschmolzenes Polymerharz aufzunehmen, wobei die Öffnung mit der Kammer kommuniziert, was es dem Polymerharz gestattet, in die Kammer einzutreten, wobei jede Öffnung vom Zufuhrverteiler gleich weit entfernt ist;
   (e) eine Oberseite des Düsenkörpers, wobei die Gesamtfläche der Öffnungen auf der Oberseite mindestens vierzig Prozent der Gesamtfläche beträgt, die durch die Breite der Öffnung und die über die primären und sekundären Düsenplatten gemessene Länge beschrieben wird;
   (f) der untere Rand von jeder sekundären Düsenplatte einen Extrusionsschlitz aufweist, der sich bis zu der Kammer erstreckt, wobei die benachbarten primären Düsenplatten mit dem Extrusionsschlitz eine Öffnung für die Extrusion des Polymerharzes bilden;
   (g) eine Einrichtung zum Abgeben eines Fluidstroms benachbart zu jeder Öffnung, umfassend einen Durchlass, der sich über die Länge des Düsenkörpers erstreckt, wobei er durch sämtliche Düsenplatten hindurchtritt,

und einen Kanal in jeder sekundären Düsenplatte aus dem Durchlass bis zu und endend an dem unteren Rand der sekundären Platte in einer Düse zur Abgabe des Fluids benachbart zum extrudierten Harz;
(h) ein Vergleichmäßigungskammersegment, gebildet von und innerhalb jeder Kombination von benachbarten primären und sekundären Platten, das ein Volumen von mindestens 2000 mal und nicht mehr als 40000 mal das Volumen der Öffnung aufweist;
(i) eine Einrichtung, um die Mehrzahl von Modulen in abgedichteter Ausrichtung miteinander zu halten.

2. Faservlies mit Fasern mit einem kleineren Durchmesser als 1 Mikron, bei dem die Fasern in der Länge durchgehend, selbstgebunden und in der Zugfestigkeit stärker als durch andere Schmelzblasverfahren hergestellte Fasern sind, und das hergestellt wird gemäß dem Verfahren:

(a) Schmelzen von mindestens einem Polymer durch eine Extrusionseinrichtung;
(b) Extrudieren des Polymers mit Fließgeschwindigkeiten von weniger als 1 Gramm pro Minute pro Öffnung durch die Düsenöffnungen der modularen Düse nach Anspruch 1, wobei die modulare Düse eine oder mehrere Reihen von Düsenöffnungen in der Maschinenquerrichtung enthält, wobei die Düse von einer Heizeinrichtung erwärmt wird;
(c) Blasen des Polymerextrudats, unter Verwendung von erwärmter Luft von mindestens 93°C (200°F), aus zwei oder mehr Niederdruckluftdüsen pro Düsenöffnung, wobei der Luftdruck weniger als 345 Kilopascal (50 psig) beträgt, zu Fasern von 1 Mikron oder weniger Durchmesser, und Ablegen der Fasern auf einer Auffangeinrichtung, die weniger als 1270 mm (50 Inches) von der Düse entfernt ist, um eine Bahn von verteilten Fasern zu bilden, die 4 Gramm oder mehr pro Quadratmeter wiegt.

3. Isolierbahn geringer Dichte, erzeugt gemäß dem Verfahren nach Anspruch 2.

4. Faservlies nach Anspruch 2, bei dem das Polymer aus der Gruppe von Thermopolymeren bestehend aus Olefinen und ihren Copolymeren, Styrolen und ihren Copolymeren, Polyamiden, Polyestern und ihren Copolymeren, halogenierten Polymeren und thermoplastischen Polymeren und ihren Copolymeren ausgewählt ist.

5. Faservliesbahn, erzeugt gemäß dem Verfahren nach Anspruch 2, bei der eine Schicht Spinnvlies auf der Bahn abgelegt ist und das resultierende Laminat unter Verwendung eines Heizpunktverbindungskalanders kalandriert ist.

6. Faservlies, erzeugt nach dem Verfahren nach Anspruch 2, bei dem eine Schicht Spinnmaterial auf jeder Seite der Bahn abgeschieden ist und das resultierende Laminat unter Verwendung eines erwärmten Punktverbindungskalanders kalandriert ist.

7. Filtermaterial aus der Faservliesbahn nach Anspruch 2, bei dem die Fasern der Bahn, die aus jeder Reihe von Düsenöffnungen erzeugt worden sind, zunehmend kleinere Durchmesser aufweisen, und die Fasern zunehmend kleiner sind und in Abhängigkeit vom Durchmesser der Düsenöffnungen im Bereich von 0,1 bis 10 Mikron liegen.

8. Elektrostatisch aufgeladene Vliesbahn nach Anspruch 2, die ein Filter ist.

9. Verfahren zur Herstellung einer Vliesbahn, das umfasst:

(a) Schmelzen von mindestens einem Polymer mittels einer Polymeraufheiz- und Extrusionseinrichtung;
(b) Extrudieren des Polymers mit Fließgeschwindigkeiten von weniger als 1 Gramm pro Minute pro Öffnung durch die Düsenöffnungen einer modularen Düse, die eine oder mehrere Reihen von Düsenöffnungen enthält, wobei die Düse durch eine Heizeinrichtung erwärmt wird;
(c) Blasen des Polymerextrudats, unter Verwendung von erwärmter Luft von mindestens 93°C (200°F), aus 2 oder mehr Niederdruckluftdüsen pro Düsenöffnung, um Fasern von 20 Mikron oder weniger Durchmesser zu erzeugen, und Ablegen des faserförmig gemachten Polymers auf einer Auffangeinrichtung, um eine Bahn von verteilten Fasern zu bilden, die 4 Gramm oder mehr pro Quadratmeter wiegt.

10. Verfahren nach Anspruch 9, bei dem die Düse, mit mehr als einer Reihe von Düsenöffnungen, in der Maschinenquerrichtung der Düse verwendet wird und jede Reihe eine zunehmend kleinere Düsenöffnung als die vorangehende Reihe aufweist.

11. Verfahren nach Anspruch 9, bei dem die modulare Düse Einrichtungen zum Extrudieren von zwei oder mehr Po-

lymeren aus derselben Düse aufweist.

12. Verfahren nach Anspruch 9, bei dem zwei oder mehr Extrusionseinrichtungen in Verbindung mit einer oder mehreren der modularen Düsen verwendet werden, wobei jede der Extrusionseinrichtungen eine oder mehrere modulare Düsen versorgt.

13. Verfahren nach Anspruch 9, bei dem der Luftdruck weniger als 345 Kilopascal (50 psig) beträgt.

14. Verfahren nach Anspruch 9, bei dem die Fasern auf dem Auffangsieb durch einen Fluidstrom abgeschreckt werden, wobei der Fluidstrom eine Temperatur von weniger als 93°C (200°F) aufweist.

15. Verfahren nach Anspruch 9, bei dem die Düsenöffnungen in getrennten Reihen von unterschiedlichen Durchmessern sind, was Fasern mit unterschiedlichem Durchmesser ergibt.

16. Verfahren nach Anspruch 9, bei dem der Winkel, der zwischen der vertikalen Achse der Düsenöffnung und dem Austrittsschlitz, der die Luftdüse oder -öffnung bildet, zwischen 0° und 60° variieren kann.

17. Verfahren nach Anspruch 9, bei dem an Stelle eines Luftschlitzes mit konstantem Querschnitt eine konvergierende-divergierende Düse verwendet wird.

18. Verfahren nach Anspruch 17, bei dem der konvergierende Teil der Düse unter einem Winkel von nicht weniger als 2 Grad und nicht mehr als 18 Grad von der Mittellinie der Düse aus konvergiert, und der divergierende Teil der Düse unter einem Winkel von nicht weniger als 3 Grad und nicht mehr als 18 Grad von der Mittellinie der Düse aus divergiert.

19. Verfahren nach Anspruch 9, bei dem 2 oder mehr Luftdüsen oder Luftschlitze zu jeder Düsenöffnung benachbart sind.

20. Verfahren nach Anspruch 9, bei dem Streckluft aus modularen Luftsystemen abgegeben wird, die durchgehende konvergierende-divergierende Düsenschlitze einschließen, wobei die Systeme unterhalb und benachbart von den Düsenöffnungsauslässen angebracht sind, wobei die durchgehenden konvergierenden-divergierenden Düsenschlitze auf beiden seiten des Polymerextrudats einen Hochgeschwindigkeitsluftvorhang bilden, wobei die Hochgeschwindigkeitsluftvorhänge von den Hochgeschwindigkeitsluftvorhängen von jeglichen benachbarten Düsenöffnungsreihen durch Platten getrennt sein können, die senkrecht zur Oberfläche der modularen Düse angeordnet sind, wobei die Platten einen getrennten Kanal zum Strecken des Extrudats mittels der Hochgeschwindigkeitsluftvorhänge bilden.

Revendications

1. Corps de filière d'extrusion modulaire pour extruder des fibres à partir de résines polymères thermoplastiques synthétiques fondues, comprenant :

   (a) un empilement de plateaux matrices primaires et secondaires en alternance ;
   (b) lesdits plateaux matrices primaires et secondaires possédant des bords supérieurs et inférieurs en alignement, séparés d'une distance non supérieure à 0,15 mètre ;
   (c) chacun desdits plateaux matrices primaires et secondaires étant traversé par une ouverture centrale, les ouvertures centrales aménagées dans lesdits plateaux matrices communiquant les unes avec les autres pour former une chambre unique de compensation continue de pression à l'intérieur dudit corps de filière, s'étendant à travers une région centrale dudit corps de filière ;
   (d) le bord supérieur de chacun desdits plateaux matrices primaires ayant une ouverture destinée à recevoir une résine polymère fondue, ladite ouverture communiquant avec ladite chambre pour permettre à ladite résine polymère de pénétrer dans ladite chambre, chaque orifice étant équidistant du canal d'alimentation ;
   (e) une surface supérieure dudit corps de filière, l'aire totale des ouvertures se trouvant sur ladite surface supérieure étant d'au moins 40 % de l'aire totale décrite par la largeur de l'ouverture et la longueur mesurée en travers de l'ensemble des plateaux matrices primaires et secondaires ;
   (f) le bord inférieur de chacun desdits plateaux matrices secondaires ayant une fente d'extrusion s'étendant vers ladite chambre, les plateaux matrices primaires adjacents formant avec ladite fente d'extrusion un orifice

pour l'extrusion de ladite résine polymère, et

(g) un moyen pour amener un courant de fluide, au voisinage immédiat de chacun desdits orifices, comprenant une voie de passage s'étendant sur toute la longueur dudit corps de filière et traversant la totalité desdits plateaux matrices, et un canal, dans chacun desdits plateaux matrices secondaires, partant de ladite voie de passage et se terminant au niveau du bord inférieur dudit plateau secondaire, dans une buse pour amener ledit fluide au voisinage immédiat de la résine extrudée ;

(h) un segment de chambre de compensation, formé par et à l'intérieur de chaque combinaison de plateaux primaires et secondaires adjacents, qui a un volume d'au moins 2000 fois et non supérieur à 40 000 fois le volume de l'orifice ;

(i) un moyen pour maintenir la multiplicité de modules en alignement étanche les uns avec les autres.

2. Tissu non-tissé ayant des fibres dont le diamètre est inférieur à 1 micromètre, lesdites fibres étant continues en longueur, auto-agglomérées, avec une résistance à la traction plus grande que les fibres préparées par d'autres techniques de fusion soufflage, et qui est produit par le procédé comprenant :

(a) la fusion d'au moins un polymère par un moyen d'extrusion,

(b) l'extrusion dudit polymère à des débits inférieurs à 1 gramme par minute par trou à travers les trous de filière de la filière modulaire de la revendication 1, ladite filière modulaire contenant une ou plusieurs rangées de trous de filière dans le sens travers, ladite filière étant chauffée par un moyen de chauffage ;

(c) le soufflage dudit extrudat polymère, par utilisation d'air chauffé à au moins 93°C (200°F), provenant d'au moins deux jets d'air sous basse pression par trou de filière, ladite pression d'air étant inférieure à 345 kilopascals (50 livres par pouce carré manométriques), pour obtenir des fibres ayant un diamètre de 1 micromètre ou moins, et le dépôt desdites fibres sur un moyen collecteur, situé à moins de 1270 mm (50 pouces) de ladite filière, pour former un voile de fibres dispersées pesant 4 grammes ou plus par mètre carré.

3. Voile isolant basse densité produit par le procédé selon la revendication 2.

4. Tissu non-tissé selon la revendication 2, dans lequel ledit polymère est choisi dans le groupe de thermopolymères constitué d'oléfines et de leurs copolymères, de composés styréniques et de leurs copolymères, de polyamides, de polyesters et de leurs copolymères, de polymères halogénés et de polymères thermoélastiques et de leurs copolymères.

5. Voile non-tissé produit par le procédé selon la revendication 2, une couche d'un matériau filé-lié étant déposée sur ledit voile, le stratifié obtenu étant calandré par utilisation d'une calandre de liage par points chauffés.

6. Voile non-tissé produit par le procédé selon la revendication 2, dans lequel une couche d'un matériau filé-lié est déposée sur chaque face dudit voile, et le stratifié obtenu est calandré par utilisation d'une calandre de liage par points chauffés.

7. Matériau filtrant obtenu à partir du voile non-tissé selon la revendication 2, dans lequel les fibres dudit voile sont produites à partir de chaque rangée de trous de filière, ces fibres ayant des diamètres de plus en plus petits, et lesdites fibres étant de plus en plus petites et ayant un diamètre de 0,1 à 10 micromètres, qui dépend du diamètre desdits trous de filière.

8. Voile non-tissé selon la revendication 2, ayant une charge électrostatique, qui est un filtre.

9. Procédé de fabrication d'un voile non-tissé, qui comprend :

(a) la fusion d'au moins un polymère par un moyen de chauffage et d'extrusion de polymère ;

(b) l'extrusion dudit polymère à des débits inférieurs à 1 gramme par minute par trou à travers les trous de filière d'une filière modulaire contenant une ou plusieurs rangées de trous de filière, ladite filière étant chauffée par un moyen de chauffage ;

(c) le soufflage dudit extrudat polymère, par utilisation d'air chauffé à au moins 93°C (200°F) ou plus, à partir d'au moins deux jets d'air sous basse pression par trou de filière, pour produire des fibres ayant un diamètre de 20 micromètres ou moins, et le dépôt dudit polymère transformé en fibres sur un moyen collecteur pour former un voile de fibres dispersées pesant 4 grammes ou plus par mètre carré.

10. Procédé selon la revendication 9, dans lequel ladite filière, qui comporte plus d'une rangée de trous de filière, est

utilisée dans le sens travers de la filière, et chaque rangée possède un trou de filière qui est progressivement plus petit que celui de la rangée précédente.

11. Procédé selon la revendication 9, dans lequel la filière modulaire possède un moyen pour extruder au moins deux polymères à partir de la même filière.

12. Procédé selon la revendication 9, dans lequel on utilise au moins deux moyens d'extrusion conjointement à une ou plusieurs desdites filières modulaires, chacun desdits moyens d'extrusion alimentant une ou plusieurs filières modulaires.

13. Procédé selon la revendication 9, dans lequel la pression de l'air est inférieure à 345 kilopascals (50 livres par pouce carré manométriques).

14. Procédé selon la revendication 9, dans lequel lesdites fibres sont brusquement refroidies sur ladite toile collectrice par un courant de fluide, ledit courant de fluide ayant une température inférieure à 93°C (200°F).

15. Procédé selon la revendication 9, dans lequel les trous de filière se trouvant dans des rangées distinctes ont des diamètres différents, ce qui conduit à des fibres ayant des diamètres différents.

16. Procédé selon la revendication 9, dans lequel l'angle formé entre l'axe vertical du trou de filière et la fente de sortie qui forme la buse ou l'orifice d'air peut varier entre 0 et 60°.

17. Procédé selon la revendication 9, dans lequel on utilise une tuyère convergente-divergente au lieu d'une fente d'air à section transversale constante.

18. Procédé selon la revendication 17, dans lequel la partie convergente de ladite tuyère converge d'un angle non inférieur à 2 degrés à partir de l'axe central de ladite tuyère, et non supérieur à 18 degrés ; et la partie divergente de ladite tuyère diverge d'un angle non inférieur à 3 degrés et non supérieur à 18 degrés à partir de l'axe central de ladite tuyère.

19. Procédé selon la revendication 9, dans lequel au moins deux buses d'air ou fentes d'air sont situées au voisinage immédiat de chaque trou de filière.

20. Procédé selon la revendication 9, dans lequel l'air d'étirage est envoyé à partir de systèmes pneumatiques modulaires comprenant des buses à tuyère convergente-divergente continues, lesdits systèmes étant placés en dessous et au voisinage immédiat desdites sorties des trous de filière, lesdites buses à tuyère convergente-divergente continues formant un rideau d'air à grande vitesse sur l'un et l'autre côtés de l'extrudat polymère, ledit rideau d'air à grande vitesse pouvant être séparé desdits rideaux d'air à grande vitesse de toutes rangées adjacentes de trous de filière par des plaques positionnées perpendiculairement à la surface de ladite filière modulaire, lesdites plaques formant un canal discret pour étirer ledit extrudat sous l'effet dudit rideau d'air à grande vitesse.

Fig. 1

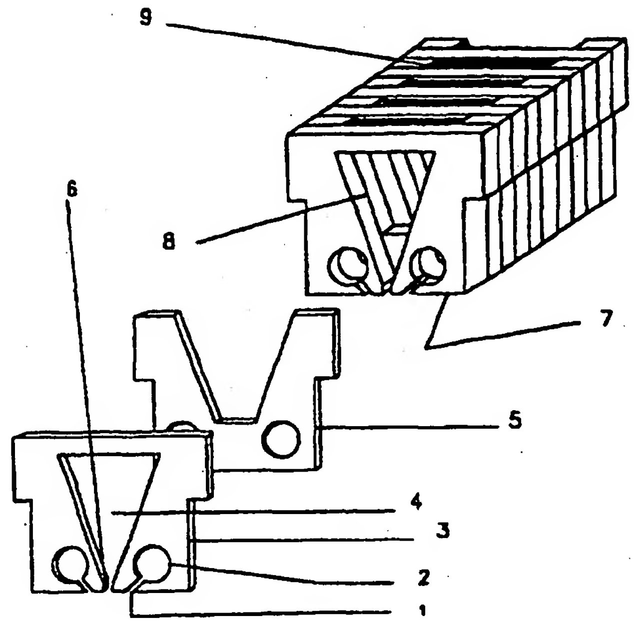

Fig. 2

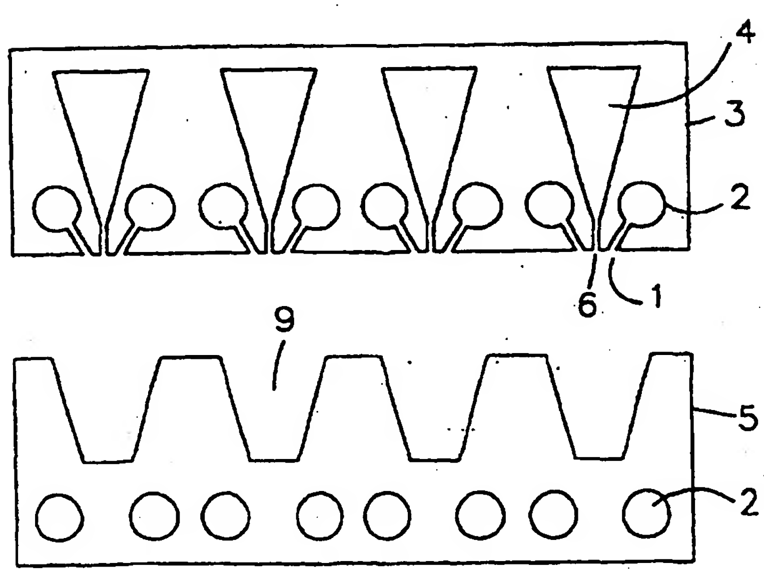

Fig. 3

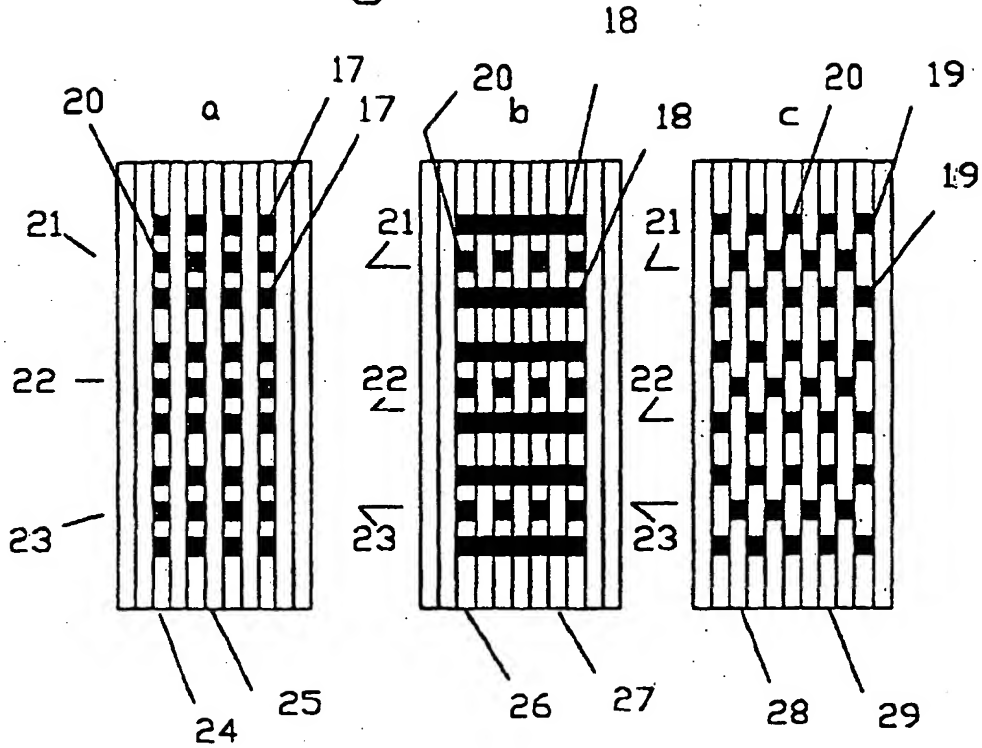
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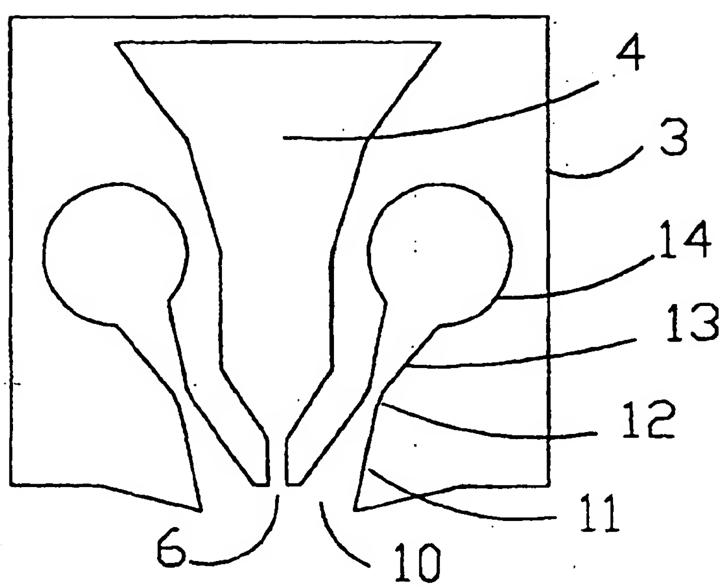
Fig. 4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